ABSTRACT

Climate Change and India's Socio-Economic Development

Jayant Sathaye and Amulya Reddy

Greenhouse gas emissions from the developing countries, including India, are projected to grow in the future. As a signatory to the Climate Convention, India needs to consider the adoption of policies and strategies to restrain emissions growth. This paper illustrates that the adoption of policies need not reduce India's social welfare. Indeed, accelerated adoption of certain energy and forestry policies will lead to reduced emissions and/or increased carbon sequestration at no additional cost to the nation. The pursuit of such policies will shift the business-as-usual growth to basic-needs oriented development, with more efficient and sustainable use of resources. However, even if the pursuit of the latter development goal reduces the life-cycle cost of abatement projects, the up front capital requirements may make it prohibitively expensive. By a judicious mix of energy and forestry options, India could sequester as much as 25% of its emissions in 2011. Forestry alternatives thus play an important role in future emission abatement strategies.

population, their share of carbon dioxide emissions in 1986 was 27% This share is increasing since their consumption of modern[5] energy is growing faster than for other countries. IPCC scenarios of future emissions indicate that worldwide emissions of carbon and other gases would continue to increase even if the developed countries were to reduce emissions from their current levels.[6] These shares suggest that the developed countries have a greater responsibility for historical emissions but the opportunities for reducing incremental emissions may be more abundant in the developing countries due to the anticipate higher growth rates.

Compared to other airborne pollutants, such as SOx and NOx, which are emitted in trace amounts, are very reactive and can be scavenged at the source, GHGs are emitted in far more diluted and much larger amounts. The diluted nature of GHG emissions poses a problem in attempting to physically remove the gases. The main alternatives consist of eliminating or reducing the emissions of these gases or growing biomass to sequester carbon dioxide.[7,8] Since much of the current deforestation occurs in developing countries, reversing or slowing this process would aid in reducing future emissions.

Developed countries have stressed that reducing GHG emissions from the developing countries is vital. If necessary, such emissions reduction could be accomplished with assistance from the Global Environment Facility (GEF).[9] On the other hand, the developing countries have argued that the growth of emissions is an unavoidable consequence of economic growth, as was the case with the industrialized countries during their past. Hence, global environmental protection should not be allowed to penalize development. Is this difference of viewpoints reconcilable?

For a signatory to the Climate Convention, the adoption of policies and strategies to restrain emissions growth is an important goal to pursue. A nation would find it easier to follow such options to the extent that these are adoptable without hindering its current or anticipated development trends. Many studies have argued

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[5] Modern energy denotes all energy derived from non-biomass sources.

[6] See Reference 2.

[7] Hall D., Mynick H. and Williams R. (1991). Cooling the Greenhouse with Biomass Energy. Nature, September 5.

[8] Hall D., Mynick H. and Williams R. (1991). Alternative Roles for Biomass in Coping with Greenhous Warming. Science and Global Security, Volume 2, pp. 1-39.

[9] GEF is a pilot programme providing grants and low-interest loans to developing countries to help them carry out programmes to relieve pressure on global eco-systems. The Facility is a cooperative venture among national governments, the World Bank, the United Nations Development Programme and the United Nations Environment Programme.

prepared for India by experts within and abroad. The CO_2 emission estimates from energy sources in these inventories are in relatively closer agreement. However, estimates of CO2 from non-energy sources, and of methane from all sources vary widely and have been debated in many fora.

Table 1.
Estimates of Annual GHG Emissions from Anthropogenic Activities in India in 1986
(Teragrams of gas)

	CO_2	CO	CH_4	N_2O	CFCs
<u>Energy</u>					
1. Coal Production			1.7		
2. Coal Combustion	378 (103)[a]	6.6	0.04	0.03	
3. Oil Combustion	114 (31)	3.9	0.01	0.01	
4. Gas Combustion, flaring	18 (4.9)	0.01	0.002	0.002	
5. Gas Venting, leakages					
<u>Industry</u>					
1. Cement Manufacture	18 (4.9)				
2. CFCs (CFC-11 Equiv.)					0.01
3. Landfills			1.7		
<u>Agriculture and Forestry</u>					
1. Animal Husbandry			10.4		
2. Rice Cultivation			37.8		
3. Fertilizer Use				0.04	
4. Biomass Combustion		55.6	3.5	0.09	
5. Deforestation, land use changes	73 (20)			0.03	
Total	601 (164)	66	55	0.2	0.01

Note: a -- Counted as carbon in CO_2.
Source: Ahuja D.(1990). <u>Climate Change Technical Series: Estimating Regional Anthropogenic Emissions of Greenhouse Gases</u> US EPA Report No. 20P-2006.

Table 1 shows the estimates of annual greenhouse gas emissions from anthropogenic activities in India for 1986. Carbon dioxide emissions total 164 teragrams[13], of which, emissions from forestry and land use changes amount to 20 teragrams. A more recent estimate places carbon dioxide emissions from fossil fuel use at 133 teragrams in 1988 compared to 139 in 1986 shown in Table 1.[14]

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[13] Teragram = 10e12 grams.

[14] Mitra A.P. (Eds.) <u>Global Change: Greenhouse Gas Emissions in India, A Preliminary Report.</u>, Scientific Report No. 1. Prepared under the auspices of Council of Scientific and Industrial Research, New Delhi, June 1991.

Table 2 shows emissions estimates for commercial energy sources for 1985 and 2025, and for biomass sources for 1986 and 2011. Emissions from energy sources increase at a rapid pace in these scenarios but those from biomass increase much more slowly in either scenario.

Table 2
Scenarios for India of Future Carbon Dioxide Emissions
(Million Tons of Carbon)

	1985	2025	Annual Growth Rate
Modern Energy Sources (1)			
High	115	703	4.5%
Low	115	615	4.2%
	1986	2011	
Biomass Sources (2)			
High	64	99	1.7%
Low	64	70	0.4%

Sources: 1. Pachauri R.K., Suri and Gupta S. (1991). CO2 Emissions from Developing Countries: Better Understanding the Role of Energy in the Long Term. Volume III, China, India, Indonesia and South Korea. July. LBL Report 30060.
2. Ravindranath N.H., Somashekhar B.S. and Gadgil M. (1992). Forests: Case Studies from Seven Developing Countries, Volume 3: India and China., August. LBL Report 32759.

Energy Efficiency and Fuel Substitution:

In 1985, the production and use of modern energy in India generated 115 million tonnes of carbon, or 10% of all carbon emissions from the developing world. Even more significant, India will account for 21% of the increase in carbon emissions produced from energy use in developing countries between 1985 and 2025.[16]

[16] Sathaye J. and Ketoff A. (1991). CO2 Emissions from Developing Countries: Better Understanding the Role of Energy in the Long Term. Volume 1: Summary. February, LBL-29507.

A recent study has shown that direct and indirect carbon emissions may be higher from construction activity than any other component of India's final demand.[19] Energy intensive materials such as glass, cement, bricks, steel, aluminum, asphalt constitute the bulk of the components of a building or any other type of structure. Thus, emissions associated with construction are large. However, reducing construction activity to decrease emissions is not a viable solution since a growing infrastructure is necessary to maintain the pace of economic development in India. Using materials more productively through improved designs of buildings and other infrastructure would be the better approach.

India's opportunities for curtailing emissions of carbon include rectifying its currently uneconomic allocation of fuels and inefficient energy-use patterns. Abundant but carbon-intensive coal resources satisfy almost 50% of India's modern energy demand. In recent years, the costs of coal production and transportation have risen due primarily to a deteriorating resource base and low productivity. Arguably, more efficient fuel options (primarily oil, natural gas and renewables) could serve as economically viable substitutes for coal in the future.[20,21]

Determining which alternatives provide the most cost-effective means for India to restrain the growth of CO2 entails a thorough economic evaluation of the available options. In the industrialized countries, economic evaluations of reducing carbon emissions have focused on taxation policies. However, in most developing countries where fiscal and technological resources are scarce, any effective emissions abatement strategy must go beyond evaluating the impact of changes in domestic taxes on levels of carbon emissions. Carbon conservation efforts must identify the types of energy-supply and use technologies needed to restrain the growth of carbon. They must also assess the capital investment and foreign exchange requirements needed to acquire less carbon-intensive technologies and fuels.

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[19] Parikh J., Gokarn S. and Barua A. (1992). Climate Change and India's Energy Policy Options. Indira Gandhi Institute of Development Research, February. Report prepared for the Rockefeller Foundation.

[20] Government of India, Bureau of Costs and Prices, Towards a New Energy Policy, Delhi, 1988.

[21] Reddy A., Sumithra G., Balachandra P. and D'Sa A. (1991). A Development-Focused End-Use-Oriented Electricity Scenario for Karnataka. Economic and Political Weekly, April 6 and April 13.

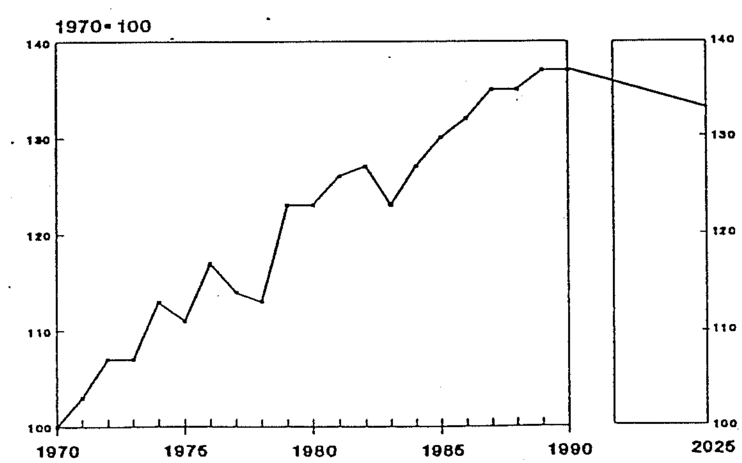
government budget. In the past, the government devoted an ever-increasing share of its budget to the energy sector. During the Sixth Five Year Plan (1980-85), for example, the government allocated 27.2% of its plan outlay to the energy sector. This share increased to 30.6% during the Seventh Plan. Even this increased share was insufficient to provide adequate power to the growing Indian economy. Power shortages are now common throughout the economy and "brown-outs" in many cities during peak periods are the norm. The government is pursuing private sector power generation to alleviate power shortages. But, the management and operation of the power sector itself must be improved prior to seeking additional financing.

Cost of Abatement:

A recent analysis of the growth of carbon emissions and the economics of abating emissions from modern energy use in India highlights the relationship between abatement strategy on the one hand and capital investment and foreign exchange or hard currency requirements on the other (Table 4).[22]

The analysis assumes growth rates for GDP and population growth (Table 4). A linear-programming model couples these rates to energy demand growth by sector and end-use. The model minimizes the cost of providing energy services to the Indian economy. Energy service may be provided by new energy supply or higher efficiency of supply and/or use. The model computes the investment and foreign exchange requirement for meeting the estimated demand for energy. Table 4 shows the foreign exchange requirement for fuel imports only.

Figure 2:
Primary Energy Per GDP India, 1970-2025
(HE scenario excluding biomass)



Source: J. Sathaye and A. Ketoff, *CO2 Emissions from Developing Countries: Better Understanding the Role of Energy in the Long Term*, Vol. 1 (LBL Report 29507 Rev., Feb. 1991)

[22] Mongia N., Bhatia R., Sathaye J. and Mongia P. (1991). Cost of Reducing CO2 Emissions from India. Energy Policy, pp.978-986, December.

In Scenario 1, energy intensity is frozen at 1985 levels. Energy sector investment as a proportion of GDP increases to 7.0% by 2005. Foreign exchange requirements increase from 1.9% in 1985 to 4.4% by 2005. In each case, the sharp increase will require that financial resources be transferred to the energy sector from other sectors which will also demand more capital and foreign exchange.

Reducing the intensity of energy use as illustrated in Scenario 2, restrains the growth of carbon emissions to 340 million tons. Since this reduction is achieved primarily through cost-effective efficiency improvement, the cost of abatement is negative.[23] The Indian economy benefits from restraining carbon emissions growth. The scenario captures the many opportunities available to use electricity more efficiently which reduce investment requirement.[24,25] However, the opportunities for reducing petroleum products demand are limited, and more difficult to implement, and this is reflected in the 4.2% foreign exchange to GDP ratio, which changes little from Scenario 1.

Switching to less-carbon-intensive fuels can further reduce emissions compared to Scenario 2. This result is achieved through either the import of natural gas as illustrated in Case 1 or through the use of renewables as illustrated in Case 2. Renewables include the use of wind, solar, hydro and biomass resources. Natural gas imports increase the foreign exchange to GDP ratio to 4.8% while reducing the investment needs. Increased use of renewables drives up the investment requirement sharply to 6.2% of GDP. Restraining emissions beyond what might be achieved through efficient fuel allocation and use would either increase capital investment or hard currency requirements.

The unit cost of conserved carbon rises from Scenario 1 to Scenario 3 as more expensive approaches are used to curtail carbon emissions (Table 4.1). By conducting alternate runs of Scenario 2 and placing progressively tighter constraints on carbon emissions, the cost of conserving carbon at levels between those in Scenario 2 and 3 were determined. For example, the cost of conserved carbon is US$ 0.02 per kilogram when emissions are reduced from 340 million to 300 million tonnes.

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[23] Net cost of abatement = Cost of providing given service through abatement strategy - Cost of providing same service by conventional means.

[24] Nadel S., Kothari V. and Gopinath S. (1991). Opportunities for Improving End-Use Electricity Efficiency in India. Report prepared by American Council for an Energy Efficient Economy for the World Bank and US Agency for International Development, November.

[25] Reddy A.K.N. See Reference 14.

These four strategies could have reduced demand for oil between 1980 and 1990 by 14.4%. More importantly these steps would have reduced the demand for kerosene and diesel by 5 million tons -- two critical middle-distillates which are imported. The result of four strategies would be a reduction of the 1985 FE/GDP ratio of 1.9% in Table 4 to 1.3%. If we assume that similar improvement may be achieved by 2005 then the ratio for Scenario 2 would fall to 2.9% from 4.2%. A lower share of GDP allocated to importing oil would make the fuel import payment more manageable.

Strategies 3 and 4 would increase demand for electricity which would add to investment requirements shown in Table 4 for 2005. As we pointed out above, there are many options to improve efficiency of electricity use that are easily implementable. The options for improving efficiency of oil use involve a diverse set of actors which make them more difficult to implement. For some end uses, such as lighting, electricity use is more efficient than oil use. Shifting to electricity in such selected end-uses would improve a nation's energy efficiency. Further, since improving electricity system efficiency may be easier than that for oil, increased electricity demand from strategies 3 and 4 could be better controlled.

In light of the cost, capital investment and foreign exchange parameters, to what extent can India restrain carbon emissions from modern energy use? Stabilization of emissions or limiting their increase to 20% over a 20-year period has been discussed for the industrialized countries. Analyses show that this goal could be achieved without a net loss of GDP in some of the countries. The Energy Modeling Forum-12 in its deliberations on scenarios assumed that restraining emissions growth to a 50% increase over a 20 year period was plausible for the developing countries.[27] In contrast, Scenario 3 in Table 4 shows that, at best, emissions could be held to 155% (280 mtons compared to 110) above the 1985 level. Further reduction in emissions would reduce annual GDP growth from the 4.9% assumed in Table 4. Indeed, we estimate that to achieve the 50% limit suggested by EMF-12 would require that the current pattern of unsatisfied energy demand continue in the future and that India's annual GDP growth be limited to 3%.[28] Most probably, these requirements would be unacceptable to India.

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[27]The Energy Modeling Forum was established in 1976 at Stanford University to provide a structural framework within which energy experts, analysts, and policymakers could meet to improve their understanding of critical energy problems. The twelfth EMF study focused on global warming and consisted of experts on economic analysis of climate change from the US and OECD countries. is Scenario assumptions for the Energy Modeling Forum - 12 on global climate change. Results of the study were widely disseminated to policy makers in these countries.

[28] Sathaye J. Carbon Emissions from Brazil, India and China. Presentation to the EMF-12 meeting in Washington D.C., May 1992.

Table 5. **India's Forestry Related Carbon Emissions and Uptake, 1986 (MtC)**

Country	Carbon Emissions (MtC)				Carbon Uptake (MtC)				Annual Carbon Balance (MtC/year)[a]	Net Committed Emissions (MtC)
	Inherited[a] (1)	Prompt (2)	Delayed (3)	Committed (4) = (2) + (3)	Inherited (5)	Prompt (6)	Delayed (7)	Committed (8) = (6) + (7)	(9) = (1) + (2) - (5) - (6)	(10) = (4) - (8)
India	26	38	26	64	68.8	n.a.	120.0	120.0	-5	-56

Notes: a. Inherited emissions for India were calculated using historic average deforestation rates for the past ten years.
Source: Makundi W., Sathaye J. and Masera O. (1992). Carbon Emissions and Sequestration in Forests: Case Studies from Seven Developing Countries, Volume 1: Summary, August, LBL Draft Report LBL-32119.

Afforestation and Development:

The carbon sequestration occurred and is occurring through programs whose main goal is to promote sustainable rural socio-economic development. Carbon sequestration is an unintended consequence of these actions. Given the potential for reducing net carbon emissions from India, the various factors that have contributed to this sequestration are worth noting. They include: (1) Establishment of the Forest Conservation Act of 1980; (2) Preparation of an environmental impact statement required with the beginning of the Fifth Five Year Plan of 1975-80; (3) Reduction of subsidies to forest-based industries beginning in late 1970s; (4) Increased industry-farmer links which has encouraged production of tree crops; (5) Decentralized political decision making. Village and district level authorities have been established in West Bengal and Karnataka, for example, that are far more motivated to ensure the prudent use of local resources; (6) Growth of strong environmental movements in different parts of the country; and (7), Biomass fuel conservation programs in all the states.

Strengthening these programs would enhance carbon sequestration and accelerate rural development. As Saxena points out in a recent article, implementation of programs will benefit some groups at the expense of others within India.[32] Most of the programs proposed in the article, such as welfare forestry on forest lands, social security plantation, farm forestry for poor, etc. will benefit the rural poor and the rich at the expense of lower level officials. However, not pursuing such programs will make everyone lose in the long run.

Favorable scenarios by Ravindranath, Somashekar and Gadgil (1991) project net uptake in 2011 from forests to be 121 million tons. Interpolating between the base year, 1986, and 2011 gives a net uptake of 57 million tons in 2005.[33] Thus, forests could offset India's modern energy related carbon emissions shown in Energy Efficiency Scenario 2, Table 4, by 17% in 2005. India's net emissions from these two sources would be reduced to 283 million tons in 2005. This would be achieved at no additional cost to those shown in Scenario 2. Further, given the exponentially higher sequestration potential for 2011, forests could offset as much as 25% of the energy emissions in 2011.

Biomass Use:

Carbon is stored away or released when the biomass from a tree is utilized. The type of use and its duration determines the net carbon emissions. A tree burnt for the purpose of land clearing will release most of its biomass immediately. A tree whose

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[32] Saxena N.C. (1989). Forestry and Rural Development. South Asia Journal, Vol.3, Nos. 1 and 2, pp.70-89.

[33] See Ravindranath N., Somashekhar B. and Gadgil M. (1992) in Table 2.

training facilities and has limited access to hardware and software. Energy efficiency agencies arê relatively powerless compared to their supply counterparts or they are part of the supply agency and have little incentive to reduce demand for their product.

Further, bilateral and multi-lateral aid agencies target the supply aspects of energy systems with inadequate attention to demand-side measures. Other issues, such as an anti-innovation attitude, the large-is-convenient funder, the project-mode sponsor contribute to the lack of attention to the three options.

Many of the barriers listed above arise because there is no incentive for the various actors to behave differently. Concern about climate change can provide this incentive. The establishment of the GEF and the growing attention being paid to environmental issues at the World Bank is a positive sign which will alter future lending practices of multi-lateral institutions.[38] Increased attention to environmental issues holds the hope that these and other similar institutions will begin to address the concerns of the poor, and not just those of the elite, in the developing countries. For example, dislocation of rural populations caused by building the Sardar Sarovar dam, coal mines and afforestation schemes are being discussed and addressed. Concern about climate change can improve environmental lending by explicitly developing projects which provide sustainable solutions to meet the energy, food, water and other needs of the poor. These projects will halt deforestation and/or lead to increased greening of rural areas in India.

Our analysis suggests that if India pursues basic-needs-oriented development with emphasis on end-use efficiency, decentralized renewables and afforestation programs, its carbon emissions growth will slow and its economy will improve more rapidly. Simultaneously, it is in the interest of the developed countries to fund India's incremental costs of switching to less-carbon-intensive technologies. Such technologies represent the most cost-effective path to economic development. For perhaps the first time in history, the interests of the developing world are aligned with those of the industrialized countries creating an unprecedented paradigm for future human development. More importantly, many of the measures to implement the three options have the potential to improve the condition of the poor in the developing countries. Efficient energy use and selected renewable options have been successfully demonstrated as necessary means to provide better water supply, lighting, and fertilizer which has fostered rural development.[39] Afforestation ongoing in India, through natural regeneration programs, directly aids rural villagers.

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[38] Reddy A.K.N. (1992). Has the World Bank Greened? Paper prepared for the Second Edition of the Green Globe Yearbook, Fridtjof Nansen Institute, Norway, September.

[39] Rajabapaiah P. Jayakumar S., Reddy A. Biogas Electricity -- The Pura Village Case Study, Chapter 18, pp. 787-816 in Johanson T., Kelly H., Reddy A. and Williams R., Eds.(1993). Renewable Energy: Sources for Fuels and Electricity, Island Press, Washington D.C.